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AUTOMOTIVE DIESEL MAINTENANCE 1. UNIT XXX, I--CATERPILLAR DIESEL ENGINE MAINTENANCE SUMMARY, II--REIEWING FACTS ABOUT ALTERNATORS.

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THIS MODULE OF A 30-MODULE COURSE IS DESIGNED TO PROVIDE A SUMMARY OF DIESEL ENGINE MAINTENANCE FACTORS AND A REVIEW OF DIESEL ENGINE ALTERNATOR OPERATION. THE SEVEN SECTIONS COVER DIESEL ENGINE TROUBLESHOOTING AND THE OPERATION, TESTING, AND ADJUSTING OF ALTERNATORS. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL BRANCH PROGRAMED TRAINING FILM "SUMMARIZING CATERPILLAR ENGINES" AND OTHER MATERIALS. SEE VT 005 655 FOR FURTHER INFORMATION. MODULES IN THIS SERIES ARE AVAILABLE AS VT 005 655 - VT 005 684. MODULES FOR "AUTOMOTIVE DIESEL MAINTENANCE 2" ARE AVAILABLE AS VT 005 685 - VT 005 709. THE 2-YEAR PROGRAM OUTLINE FOR "AUTOMOTIVE DIESEL MAINTENANCE 1 AND 2" IS AVAILABLE AS VT 006 006. THE TEXT MATERIAL, TRANSPARENCIES, PROGRAMED TRAINING FILM, AND ELECTRONIC TUTOR MAY BE RENTED (FOR $1.75 PER WEEK) OR PURCHASED FROM THE HUMAN ENGINEERING INSTITUTE, HEADQUARTERS AND DEVELOPMENT CENTER, 2341 CARNEGIE AVENUE, CLEVELAND, OHIO 44115. (HC)

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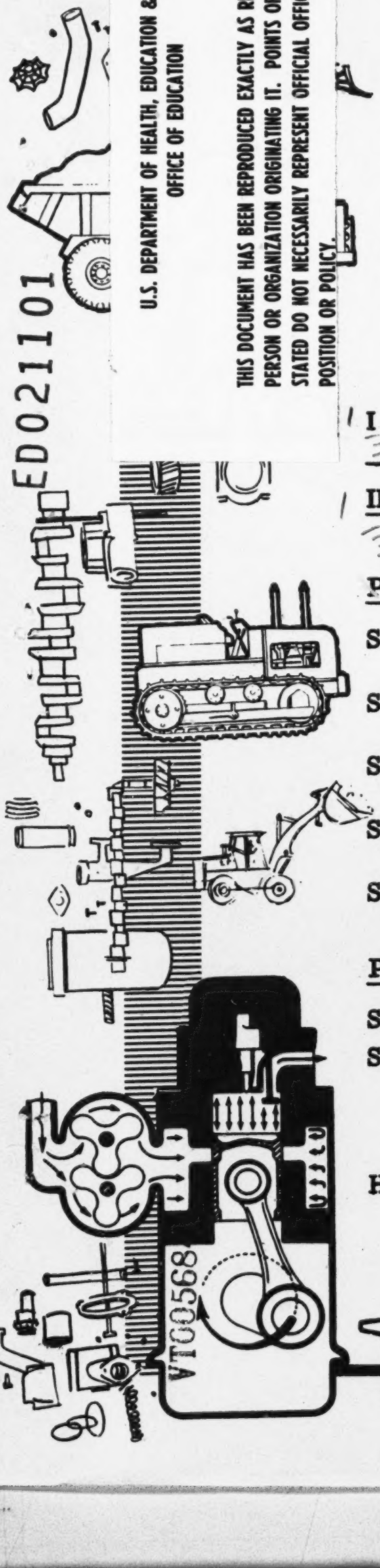

STUDY AND READING MATERIALS

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AUTOMOTIVE DIESEL 1 MAINTENANCE

I -- CATERPILLAR DIESEL ENGINE MAINTENANCE SUMMARY

II -- REVIEWING FACTS ABOUT ALTERNATORS

UNIT XXX

Part I

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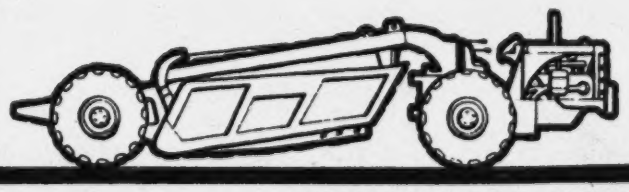


HUMAN ENGINEERING INSTITUTE

This unit is divided into two parts. The first part covers some trouble-shooting tips on different models of Caterpillar engines and equipment. The second part is a brief review of alternator operation.

I -- CATERPILLAR DIESEL ENGINE MAINTENANCE SUMMARY

SECTION A -- TROUBLESHOOTING THE ENGINE ON 988, 824, and 834 CAT LOADERS AND DOZERS

EXCESSIVE BLACK EXHAUST SMOKE AND LACK OF POWER -- If the air cleaner plunger rises to red when revving up the engine, change the air cleaner elements. Restriction should not exceed 18" of water with a gauge or manometer.

Re-check the back pressure with the air pressure gauge or manometer after the filter elements have been changed. Restriction should be from 3" to 6" on a new or washed filter element.

LOW FUEL OIL PRESSURE -- If pressure is low when the engine is running at full speed, check the primary fuel filter. If dirty, clean it and replace the element.

Replace the secondary fuel filter elements and clean out the housing.

Check the fuel pump by-pass for:

a. Particles of dirt between the check valve and seat.
b. Bad seat on the check valve.
c. Spring for proper tension.
d. Clogged fuel line.

LOOSE OR FAULTY LINKAGE -- Depress throttle fully to bottom. Remove the governor control rod pin and check to see if the governor lever

goes to the full fuel position. If not, adjust the control rod.

NOTE: To make this check, the rack limiter plunger will have to be removed. The rack limiter will not allow the engine speed to exceed approximately 1150 rpm.

LOW OIL PRESSURE -- If oil pressure is below 8 to 10 pounds, the rack limiter will not allow the engine speed to exceed 850 rpm.

Determine the cause of the low oil pressure. See manual for given engine.

FAULTY RACK LIMITER -- Check for plugged air tube between the intake manifold and rack limiter diaphragm.

Check rack limiter diaphragm for leak by using a 24" long tube with proper fittings. Connect the rack limiter and blow into the tube by mouth; if there is an indication of leakage, replace the diaphragm.

NO RESPONSE TO GOVERNOR -- ENGINE RUNS AT ONLY ONE SPEED AND MISSES -- Determine which cylinder is missing, by loosening the fuel injector tube nuts (one at a time). A firing injector will produce a definite miss when you loosen the injector tube.

When there is no change in the running of the engine with the injector tube loose, the injector is malfunctioning. Usually this is caused by a scored and frozen injection pump, freezing of the fuel rack or the fact that the injector is "hung" at the uppermost travel of the plunger stroke. With this condition, there will be no fuel being injected by this injector. This situation often is caused by contaminated fuel.

Replace faulty injector:

a. It will be necessary to use force to remove the injector body from the plunger. Use extreme caution so as not to damage the fuel pump housing.

b. After removal, check the lifter yoke for excessive wear by installing new pump plunger and checking up and down play. If any play is present, replace the yoke and adjust to proper setting (refer to the service manual).

c. Install new fuel injection pump; make sure plunger is properly timed to rack when installing.

ENGINE SPEEDS UP BUT MISSES -- Follow these steps:

1. Check for loose injection tube nut or broken injection tube.
2. Loosen injection tube nuts (one at a time) to determine missing cylinder.
3. Remove injection pump that is not firing. Check the lifter yoke adjustment and re-adjust if necessary.
4. Install new injection pump (make sure plunger is properly timed to fuel rack).
5. If engine still misses, remove hood, steam clean top of engine, remove valve and cam shaft housing cover and replace fuel injector valve assembly.
6. At this time, before replacing valve and cam shaft housing cover, it is advisable to check the valve clearance and compression release clearance and clean if necessary.
7. Start and bleed fuel systems.

CHECKING TURBOCHARGER -- Much has been said about the turbocharger in past units. For one that is not operating properly, follow these steps:

1. Accelerate engine and listen for noise (whine) of turbo as engine is slowing down. If this (whine) is not present, it is an indication that the turbo is faulty (inoperative) on 824 models - 4 cylinder engines.
2. Check turbo by-pass valve, making sure that it is not stuck in the open position.
3. Remove air ducts and check turbocharger rotor shaft bearings for excessive wear and play in rotor itself. If excessive, replace the turbocharger.

SECTION B -- TROUBLESHOOTING THE CATERPILLAR D8 ENGINE

The following represents a check list to use when locating difficulties that occur in Caterpillar D8 crawler tractors.

ENGINE SMOKES BLACK AND SHOWS LACK OF POWER

1. Check air induction tubing for restriction.
2. Check air cleaner.
3. Check turbocharger -- see manual.
4. Check valves.

Cause of excessive black smoke is too much fuel and lack of air.

ENGINE SMOKES WHITE

1. Check rack.
2. Check nozzle.
3. Check valve.
4. Check lifter setting.

Bad combustion such as bad valves, rings or worn liners can also cause this condition.

TURBOCHARGER

1. Remove intake pipes and check end play with dial indicator -- see manual for correct tolerance.
2. If there is any sign of oil in compressor or turbine housing the turbo should be disassembled and checked.

LOW OIL PRESSURE

1. Check for faulty gauge.
2. Remove oil filters, cut them open and inspect for metal or aluminum particles. Any particles found in the filter have to pass through the oil pump.

3. Check oil level.
4. Check oil pump.

LOW FUEL PRESSURE

1. Check fuel filters.
2. Check fuel gauge.
3. Remove and clean by-pass valve. Also inspect for wear. Replace if valve shows any sign of wear.
4. Loosen fuel line from tank to fuel pump and see if there is any restriction of fuel flow.
5. Remove, disassemble and check fuel transfer pump.

LOW POWER

1. Check all items listed under the headings:
   - ENGINE SMOKES BLACK AND SHOWS LACK OF POWER
   - ENGINE SMOKES WHITE
   - LOW FUEL PRESSURE
2. Remove and test all injector pumps and nozzles.
3. Check lifter setting.
4. Check fuel rack with a 3H1690. See rack index chart for correct setting. However, do not tamper with rack if this gauge is not available. The Cat fuel pump rack is adjusted in 1000th of an inch and therefore should not be moved unless the proper tools are available.

ENGINE HAS UNUSUAL VIBRATIONS AT CERTAIN RPM's

1. Check vibration damper. This damper should be warm after operating a short time. A cold damper means it is ineffective.
2. Check for a broken crankshaft.
3. Check for loose or worn "U" joint on master clutch output shaft or front "U" joint if unit is equipped with front control.

SECTION C -- TROUBLESHOOTING THE CATERPILLAR STARTING ENGINE

Much has been said in past units about the Caterpillar starting engine. This section reviews some of the pertinent data about this engine, and outlines the troubleshooting procedure for different systems.

GENERAL DESCRIPTION -- Caterpillar uses two basic starting engines for all applications. The smallest one is a 2-3/8" bore by a 2-3/8" stroke. This engine is used in all applications up to the 5.4 diesel engine. The larger engine is a 3-5/8" bore x 4" stroke. This engine is used in all applications where the diesel engine has a 5.4" bore and larger. Both engines are of independent lubricated, four cycle gasoline engine design. We will first review the smaller 2-3/8" bore and 2-3/8" stroke engine. This engine has a brake horsepower of 12 to 15 at 4,500 rpm. The high idle is 5,050 rpm at governed speed. The low idle is at 2,250 rpm.

This starting engine is made up of two piston assemblies driven by a crankshaft. The crankshaft is supported by two main bearings -- one on each end. The connecting rods have bearing inserts, and oil pressure is supplied to them through the main bearing. The crankshaft also drives a gear, which in turn drives the camshaft which operates the push rods, rocker arms and valves. Each piston assembly is equipped with two rings, one compression top and bottom oil ring. Piston pin is of the floating type and therefore is not a press fit in the pistons. They are connected to the crankshaft with a lower bearing shell, which is held by two bolts and two nuts on each connecting rod. The torque on these nuts is quite critical; when installing new or used bolts and nuts on connecting rods you should consult your service manual for the proper torque.

FUEL SYSTEM -- This engine uses a one gallon fuel tank. No fuel pump is used. It is a gravity flow to the carburetor. There is a shutoff valve

in the fuel line which should be shut off at all times except while the starting engine is running. The only fuel filters used on this engine are the ones used in the tank where there is a small screen, and a filter in the sediment bowl. The carburetor uses a dry type air element for filtration of intake air. It is a down-draft type with two adjustments. The small adjustment is used for idling and the large metering valve is used for all adjustments other than idling.

ELECTRICAL SYSTEM -- Electrical system on this engine consists of a 12 volt storage battery, a magneto, wiring and two spark plugs. The magneto is driven directly by the camshaft and consists of a transformer, contact breaker, loader, condensor and distributor. When this unit is correctly timed to the engine it will deliver the right amount of spark at the correct time for firing. To time this magneto to the engine, you rotate the starting engine until No. 1 piston is at top dead center and then you align the X on the tang of the magneto with the X in the groove on the camshaft of the starting engine. Bolt the magneto securely to the block; after this there is no way to adjust the timing on this unit. The electric starter used on this engine is basically the same as all 12 volt Delco starters used in automotive applications.

LUBRICATION SYSTEM -- This engine has its own oil pump, using an independent lube system. Oil pressure at high idle should be not less than 40 psi. The pump is a gear type, driven directly by the crankshaft. It also is equipped with a pressure regulating valve which consists of a spring loaded ball held in place by a core plug and cotter key. The newer versions of this engine are equipped with a full flow oil filter. This oil filter has a by-pass valve located in the filter base. The oil capacity on this engine is 4 1/2 quarts. The oil pump supplies pressure oil to all moving parts of the engine and also to the transmission and clutch arrangement of this starting unit.

STARTING ENGINE CLUTCH AND TRANSMISSION ARRANGEMENT -- The clutch is an automotive type with pressure plate and two discs. It also is

equipped with a brake for stopping the starter pinion. Both controls are equipped by a single lever. The adjustment on this lever is critical (see operator's manual for correct adjustment). The clutch drives a starter pinion through an idler gear. The pinion is equipped with an automatic kick-out device and a one-way clutch to prevent overspeeding of the starting engine. There is no adjustment on the automatic kickout device. It is operated by centrifugal force. When the single lever on this unit is properly adjusted, the bendix or starter pinion should stay fully engaged until the diesel engine is running, then automatically return to neutral.

TROUBLESHOOTING THE STARTING ENGINE ELECTRICAL SECTION -- Engine will not turn over:

1. Check battery and all battery connections. Check all wires leading to starter switch. Check starter to see if it will turn.
2. Engine will turn over but will not fire. Remove and service spark plugs. Replace if necessary. Check timing on engine. There is no way for this engine to get out of time unless there has been a malfunction in the gear train or magneto. Check magneto for proper spark. To do this, you can leave No. 1 cylinder spark plug wire hooked to the spark plug. Remove spark plug from cylinder head and ground somewhere on the engine. Crank engine. You should see a small spark between the electrodes on the spark plug. If you have no spark to the plug, then trace back to the wiring. If wiring proves to be ok, then remove cap from magneto. Check points, condenser and coil. To properly check the magneto, it is easier to remove from engine. Disassemble and make necessary repairs. The proper point gap on a magneto is .015".

TROUBLESHOOTING THE STARTING ENGINE CLUTCH AND TRANSMISSION ARRANGEMENT -- If the starting engine will run but will not turn the diesel engine, proceed as follows:

First check to see that diesel engine is not locked up. To do this, either turn diesel engine with fan or through the flywheel. If engine will then turn

it is not locked up, and the trouble lies in the starting engine transmission and clutch arrangement. Check all linkages leading from pinion control lever on starting engine housing. After this has been checked and has been cleared, then check for proper clutch and brake adjustments. To do this, remove side panel on clutch housing. See service manual for proper clearances on clutch pressure plate fingers.

SECTION D -- REMOVING THE STARTING ENGINE FROM A CATERPILLAR 824 TRACTOR

This section outlines the correct procedure for removing the starting engine from a CAT 824 tractor. For other CAT equipment, check the maintenance manual for differences in procedure.

REMOVAL --

1. Disconnect the ground cable at the battery.
2. Drain the diesel engine cooling system.
3. Remove the hood.
4. Close the starting engine fuel shut-off valve.
5. Drain the starting engine crankcase and remove the oil filter.
6. Disconnect the crankcase drain hose.
7. Disconnect the bracket which secures fuel block, and position the assembly where it will not interfere with the removal.
8. Disconnect the terminal board (located inside the junction box from the tractor frame).
9. Attach the lifting bracket, specially made for this operation, to the starting engine.
10. Attach a hoist to lifting bracket that will support the engine weight, see Figure 1. (Approximate engine weight is 250 pounds).
11. Remove the engine mounting bolts and bolts that secure the transmission oil cooler to the starting engine.

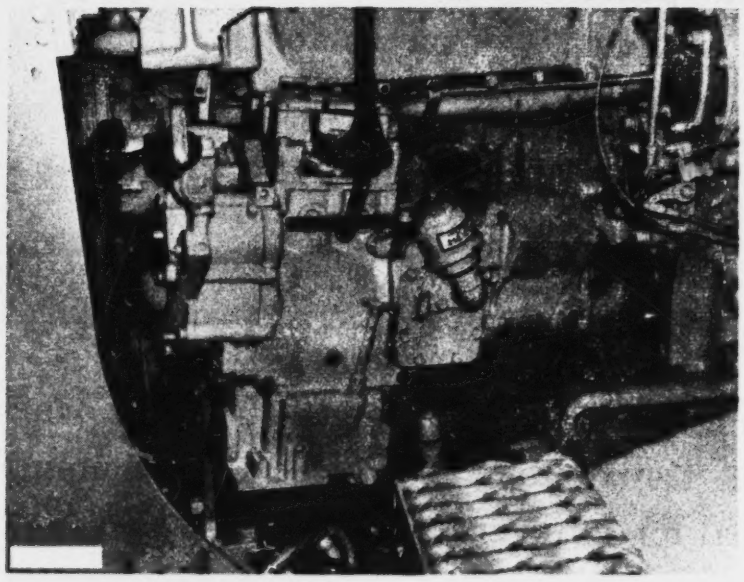


Fig. 1 Removing starting engine

12. Move the starting engine forward until pinion housing clears the diesel engine flywheel housing.
13. Before re-installing the starting engine, be sure to replace all damaged gaskets and seals.

SECTION E -- TROUBLESHOOTING THE CATERPILLAR NO. 12 MOTOR GRADER

INITIAL INSPECTION TIPS -- To eliminate unnecessary disassembly of this piece of equipment, especially when the complaint is unsatisfactory operation of the motor grader controls, it is a must for the mechanic to inspect the linkage for bent members or for any obstruction that could interfere with movement of the linkage. The vulnerability of the linkage to falling rocks, and other foreign material, plus many connecting joints where wear can occur, makes it more probable that the source of trouble is external.

Operate the implements and try to analyze the malfunction. Possible trouble sources can generally be eliminated by what you see and feel. The following chart (Table I) offers some guidance in troubleshooting the motor grader hydraulic controls.

SYMPTOM	CAUSE	REPAIR
Erratic and noisy operation of all four power controls is worse at high idle than low idle.	Pump cavitation due to low oil pressure that has been caused by 1. Obstruction in suction line. 2. Plugged filter and sticking by-pass valve.	Drain oil from control box, inspect by-pass valve and suction line. Install new filter. Refill to proper level.
Erratic and noisy operation of all four power controls at both high and low idle.	Gear noise.	Inspect vertical drive bevel-gear, idler gears, and clutch drive gears for worn or broken teeth and worn bushings or bearings.
One of a pair of power controls shows low oil pressure in one or both directions. OR: Ratcheting of jaw clutch in only one dual clutch assembly.	1. Partially stuck limit or dump valve. 2. Leaking seal. 3. Damaged spool valve or manifold passages in casting.	1. Inspect and clean limit valves for the malfunctioning power control. When reinstalling limit valves be sure to bleed air from the valve and lines by depressing the limit valve manually while moving arm away from limit valve at low idle until air is exhausted. Repeat for both limit valves. 2. Replace seal. The control lever shaft seals at the control valve assembly could be sources of this type of trouble. Also, seals between control assembly body and clutch housing.

Table I Troubleshooting the Caterpillar No. 12 motor grader

SYMPTOM	CAUSE	REPAIR
A power control will not engage, there is no audible ratcheting, and oil pressure is satisfactory.	1. Clutch piston or sliding clutch. is cocked or jammed in clutch. 2. All jaw teeth are worn off.	Disassemble and inspect the dual clutch assembly that is giving trouble.
A jaw clutch will not disengage.	1. Sticking spool valve. 2. Damaged return spring.	Inspect spool valve for damage or dirt causing it to hang up in the housing.
Blade will not raise or lower and there is no audible ratcheting.	1. Dump valve unseated. 2. Loose plug in clutch brake housing. 3. Limit valve stuck open.	1. Replace dump valve spring. 2. Tighten or replace plug in brake housing. 3. Correct cause of sticking limit valve.
A power control clutch will not engage and there is no audible ratcheting.	1. Worn jaw teeth. 2. Low oil pressure.	1. Replace sliding clutch or drive gears having worn jaw teeth. 2. Locate leaking seal or other cause of low oil pressure.

Table I Troubleshooting the Caterpillar No. 12 motor grader (cont'd.)

SYMPTOM	CAUSE	REPAIR
Low oil pressure of either the right or left hand pair of power controls. OR: A right or left hand pair of controls do not work and there is no sound of ratcheting.	1. Low relief valve setting. 2. Blown seal on pressure line from pump to control valve. 3. Lines to limit valves crosses during installation. 4. Loose relief valve. 5. Worn or damaged pump.	Check oil pressure at pressure taps in limit valves. Oil pressure should be 1040 at low idle. The relief valves are accessible after removing large nut on either side of the power control box. Valve setting is increased by adding shims under the valve. If added shims do not raise the oil pressure, inspect the pump and seal on pressure line to the control valve. The seal on the pressure line from the pump is easily checked by removing the pump.

THE IMPLEMENT HYDRAULIC CIRCUIT

Low oil pressure for all hydraulic implements.	Low relief valve setting.	The relief valves for both sections of the pump are contained in one housing. The housing is located on the right hand side of the power control box on the No. 12F and the No. 14E. The relief valve for the steering booster and brake system should be set at 1000 psi. and the valve for the hydraulic implement system at 1350 psi.
Low oil pressure for all hydraulic implements.	Worn or damaged pump.	If added shims do not raise the oil pressure, check the pump for wear.

Table I Troubleshooting the Ceterpillar No. 12 motor grader (cont'd.)

SYMPTOM	CAUSE	REPAIR
Erratic action of only one hydraulic implement.	Bent linkage or wear at pinned joints that causes spool to be out of position. Sticking valves.	Check external linkage for wear or slop and make sure that spool valve has full travel. Make sure that all valves in the particular circuit are moving freely (flow control, load-lock and check valves).
Implement having flow control valve in circuit will not operate.	Incorrect installation of flow control valve.	Flow control valve can be installed end-for-end but will not operate in this position. Check by engaging the next valve. If the flow control valve has been installed backward, the next valve will not operate, for all oil flow has been stopped by the flow control valve in the first control valve.
Implement with dummy valve in the circuit will not operate.	Dummy valve installed end-for-end.	Same as above.
Implement will not operate.	Dummy valve or flow control valve omitted.	Check other control valves in circuit. All that have either a dummy valve or flow control valve will operate.

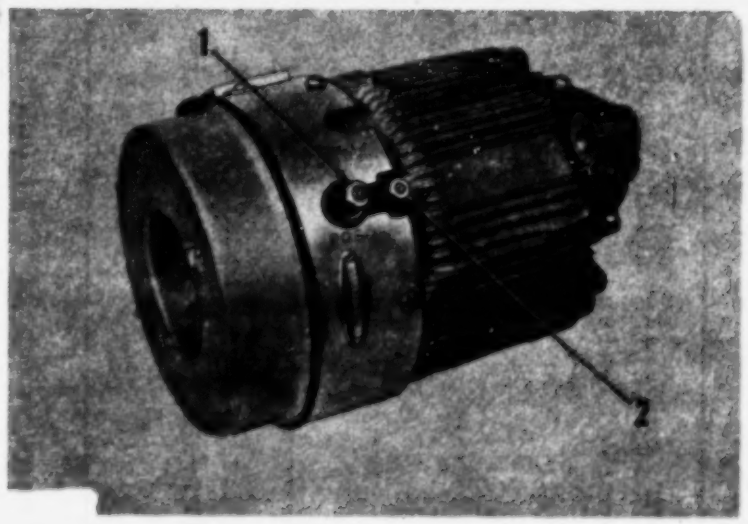
Table I Troubleshooting the Caterpillar No. 12 motor grader (cont'd.)

II -- REVIEWING FACTS ABOUT ALTERNATORS

SECTION A -- OPERATION OF THE ALTERNATOR

LOCATION -- The alternator is located on the upper left side of the engine. It is belt-driven from the engine fan pulley and supplies the electrical power.

The alternator is a self-rectifying brushless unit with a built in regulator. The only terminals on the alternator are the output terminal (1) and a ground terminal (2). The output terminal sometimes is referred to as the battery terminal, see Figure 2.



1-Output terminal. 2-Ground terminal.

Fig. 2 Alternator

OPERATION -- When the rotor starts to turn, AC voltages are built up in the stator windings. The energy needed for the initial build up of voltage is provided by the permanently magnetized rotor core. This special core is required since the field winding is not energized when the rotor first begins to rotate.

AC voltages are impressed across the diodes marked (D-2), (D-3) and (D-4), see Figure 3, which produce a current flow from the stator windings through these diodes and then through the resistor (R-1), the diode (D-1), the transistor (TR-1) and on through the generator field winding to ground. When the alternator begins to operate and reaches a preset value, the other components in the regulator in effect turn TR-1 on and off, making this transistor either resistive or conductive. When it is resistive, it acts like open contact points and inserts high resistance into the alternator field circuit, thus cutting down generator voltage. As voltage falls, TR-1 is turned on again and it becomes highly conductive, just like closed contact points. The transistor action thus controls alternator voltage.

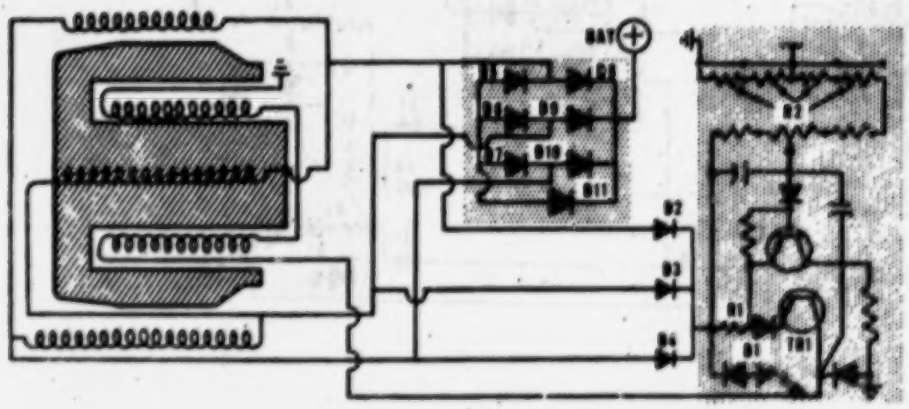


Fig. 3 Wiring diagram (12 volt)

Current returns to the stator windings through the rectifying diodes (D-5), (D-6) and (D-7). Thus, the stator windings supply current to the field winding and the field winding creates magnetism in the revolving rotor needed for full voltage build-up in the stator windings. The stator voltages are then rectified to a DC voltage by six diodes marked (D-5) through (D-10).

The DC voltage appears at the output or "BAT" terminal on the alternator and the alternator then supplies DC or direct current to charge the battery and operate the accessories.

The value of the DC voltage output is determined by the amount of current flowing in the field winding. The field current is controlled by various components in the regulator which act together to cause transistor (TR-1) to turn on and off the field current, as previously explained.

A by-pass diode (D-11) is provided to prevent damage to the rectifying unit upon accidental reversal of battery current. On some later models, the four step voltage resistors (R-2) are eliminated and voltage adjustment is made with a potentiometer alone. (Figure 4 shows a schematic of the 24 volt alternator circuit).

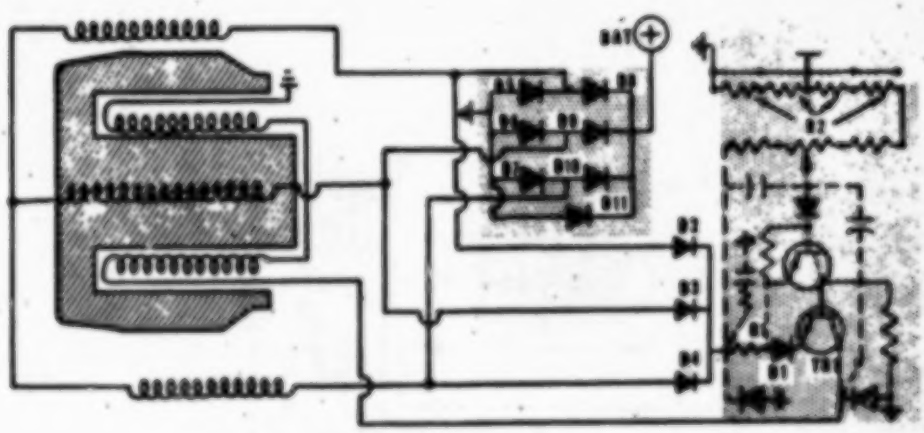


Fig. 4 Wiring diagram (24 volts)

CAUTION -- Do not attempt to polarize alternator, and if at all possible do not make or break any alternator connections with the alternator operating. Before using booster cables to start a machine, disconnect the alternator output terminal lead. Remove all unnecessary load from the circuit and take care not to accidentally short between ground and output components when reconnecting terminal lead. Making or breaking an alternator connection with a heavy load on the circuit will sometimes result in regulator damage. Always be ABSOLUTELY SURE that the battery ground polarity and the charging system polarity are the same when installing a battery. If a battery is hooked up backwards, it is

directly shorted across the alternator diodes. The high current flow can damage the diodes and even burn up the wiring harness. If the battery post identification is not obvious, use a voltmeter across the posts to identify their polarity. DO NOT polarize an alternator. The reason a DC generator is polarized is to excite the generator field to insure that the generator and the battery will have the same polarity.

Since the alternator develops voltage of both polarities, which the diodes automatically rectify, there is no need to polarize an alternator. In fact, damage to the alternator, regulator or circuits may result from an attempt to polarize the alternator. NEVER short across or ground any of the terminals on either the alternator or the regulator. Care should be exercised when working in the engine compartment to avoid accidental shorting of the alternator or regulator terminals, either accidentally or deliberately.

DO NOT operate an alternator on an open circuit. Operating the alternator while it is not connected to a battery or to any electrical load will cause the voltage to be extremely high. This high voltage may damage the diodes or other components.

The booster battery MUST BE correctly connected. When a booster battery is used to assist in engine starting (or for any other reason), it must be connected to the slave battery in proper polarity to prevent damage to the diodes and other components. The positive cable must be connected to the slave battery positive terminal and negative cable from the booster battery must be connected to the slave battery negative terminal. In other words, positive-to-positive and negative-to-negative.

CAUTION: Always connect the cables to the slave battery first, then to the booster. A spark jumping over a run-down battery can cause an explosion of the hydrogen gas that has accumulated.

Battery charger MUST BE correctly connected. When charging a battery,

disconnect the battery cables before connecting the charger leads to the battery to prevent possible damage to the alternator. A fast battery charger should never be used as a booster for starting the engine equipped with an alternator.

ALWAYS disconnect the battery ground cable before replacing or servicing electrical units.

SECTION B -- ALTERNATOR TESTING AND ADJUSTING

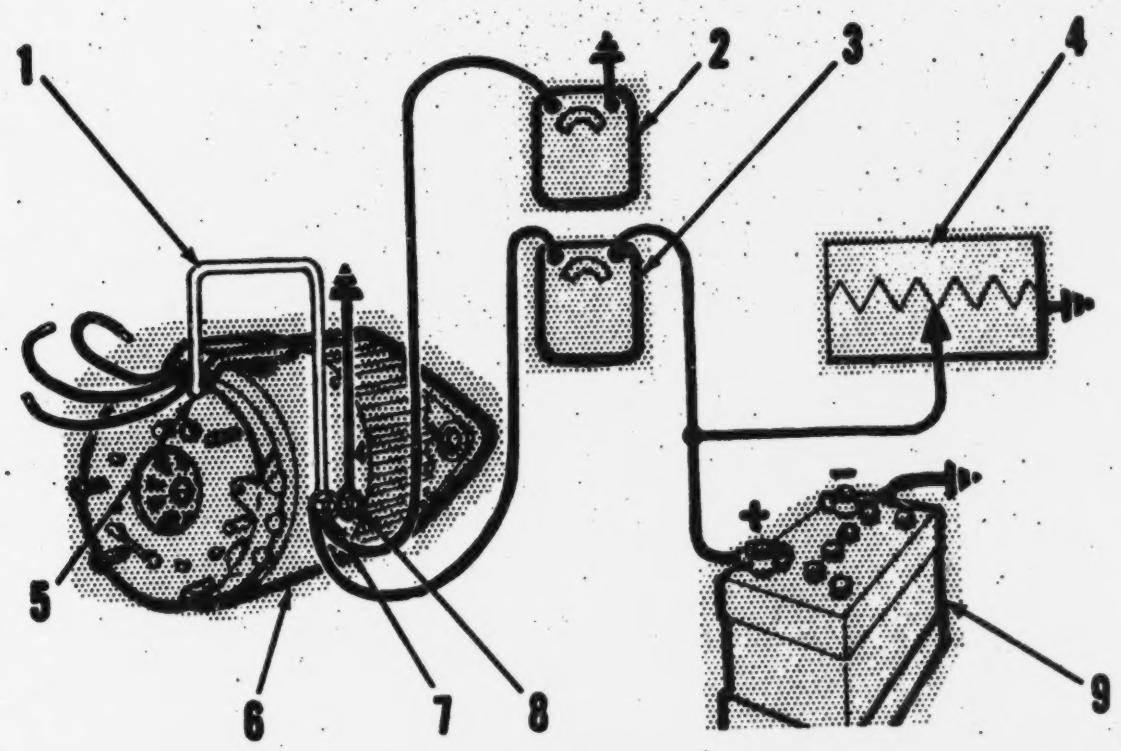
Trouble in the electrical system usually will be indicated by one of two conditions -- an undercharged battery or an overcharged battery. Either can result from an improper voltage regulator setting, or from a defective battery. The battery should be checked first, to insure it is not defective, before checking the charging alternator.

NOTE: For correct initial voltage regulator setting, refer to the CAT manual.

CHECKING ALTERNATOR OUTPUT WITHOUT REGULATOR IN CIRCUIT -- (Shown in Figure 5). CAUTION: Do not allow the voltage to exceed the recommended regulator voltage setting listed in the CAT manual.

NOTE: If the voltage setting is not steady, or if it cannot be adjusted to a value reasonably close to the listed specifications, trouble in the alternator or regulator components is indicated. See Shop Manual for details and specifications.

Ohmmeter readings vary considerably when checking diodes; however, a good diode will give one very low reading and one very high reading.

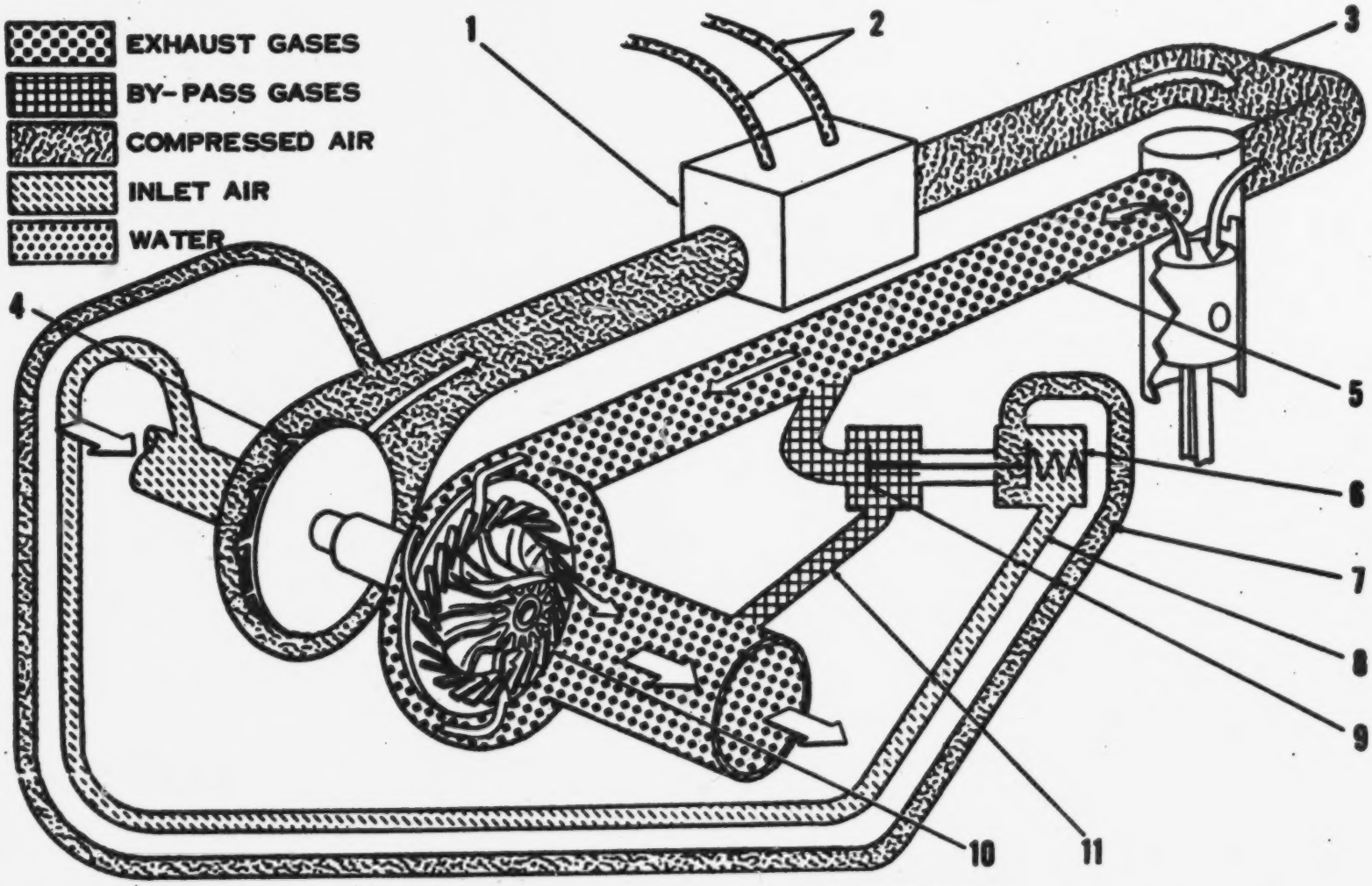


1-Jumper lead. 2-Voltmeter. 3-Ammeter. 4-Carbon pile. 5-Field wire (red). 6-Charging alternator. 7-Output terminal. 8-Ground terminal. 9-Battery.

Fig. 5 Testing schematic

When replacing a diode, make sure the polarity of the new diode matches the polarity of the old diode. Diode cases are marked with either a plus or a minus to identify the polarity of the case. Negative (-) diodes have right hand threads and positive (+) diodes have left hand threads. Since diodes have pipe threads, the depth of penetration may vary from one diode to another. Tighten to the torque value given in the specifications.

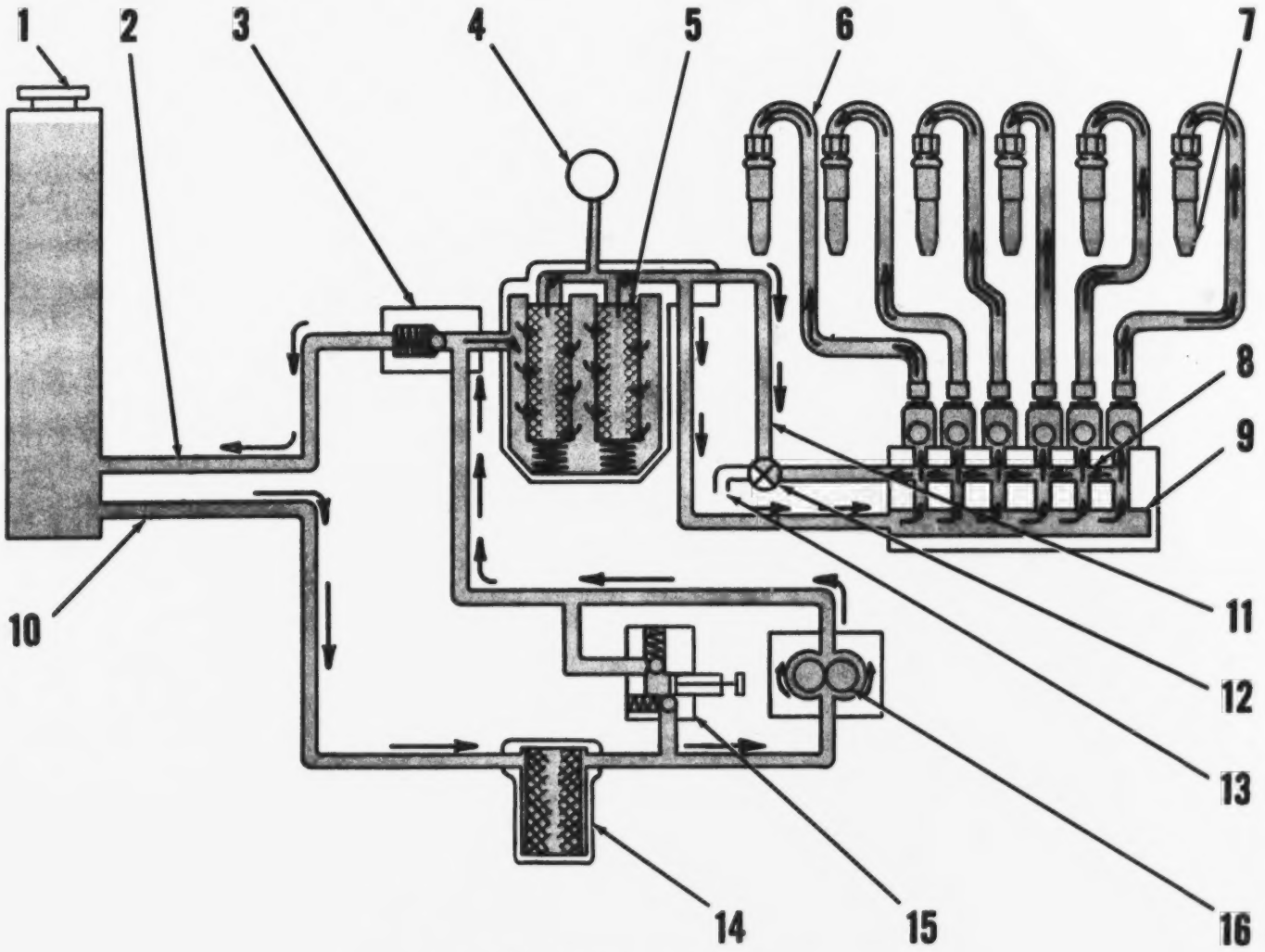
DIDACTOR PLATES FOR AM 1-30D



AIR INDUCTION AND EXHAUST SYSTEM (SCHEMATIC)

1–Aftercooler. 2–Water lines. 3–Inlet manifold. 4–Turbocharger impeller. 5–Exhaust manifold. 6–Air pressure ratio control regulator. 7–Line (inlet manifold pressure). 8–Line (impeller inlet pressure). 9–Bypass valve. 10–Turbocharger turbine. 11–Exhaust bypass tube.

Plate I Air induction and exhaust system.

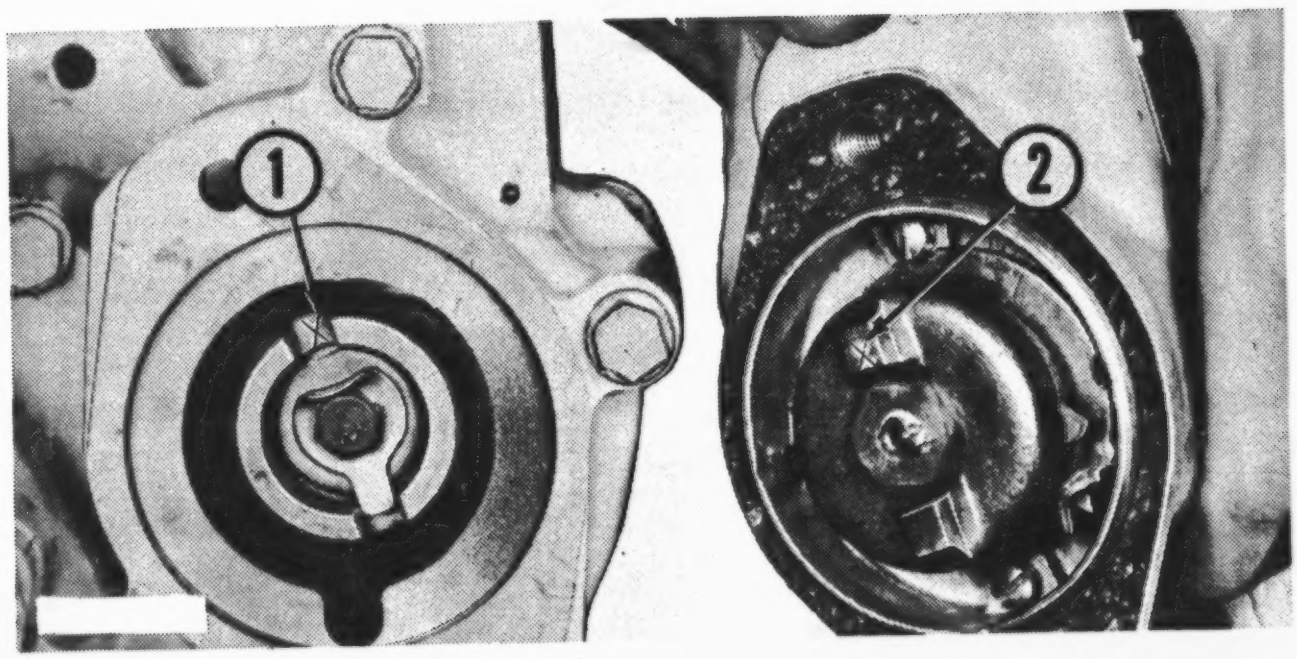


FLOW OF FUEL (SCHEMATIC)

1–Supply tank.
2–Return line.
3–Bypass valve.
4–Pressure gauge.
5–Fuel filter.
6–Fuel injection line.
7–Fuel injection nozzle.
8–Air bleed manifold.
9–Fuel manifold.
10–Supply line.
11–Air bleed passage.
12–Air vent valve.
13–Vent line.
14–Primary filter.
15–Priming pump.
16–Transfer pump.

Fig. 1 Flow of fuel through a six cylinder CAT.

Plate II Flow of fuel.



1–Mark on engine drive. 2–Mark on magneto drive.

Plate III Matching up magneto.

0

AM 1-30D
11/4/66

SUMMARIZING CATERPILLAR ENGINES

Human Engineering Institute
Minn. State Dept. of Ed. Vocational Education

Press A 1 Check to see that timer is OFF

1

This film lesson is basically a review of the previous nine text units and film lessons on Caterpillar engines and equipment. Questions will be asked that you should have little difficulty in answering. However, if you miss the questions, corrective frames are given. Read every frame carefully and think before answering.

Press A 2

1

2

In our study of Cat engines, we found that the air intake and exhaust system was very similar to other diesel engines. One thing that is noticeably different is that CAT engines are usually equipped with_____.

3 A. after coolers
5 B. turbochargers
4 C. super chargers

1

3

No. An after cooler, or heat exchanger as it is sometimes called, is standard equipment on the CAT engines. The Cummins engine has a similar device that performs the same function. The answer we want here is that CAT engines usually are equipped with turbochargers.

Press A 5

1

4

No. Turbochargers is the answer. CAT engines are rarely found with superchargers, just as GM engines are rarely found with turbochargers. Most CAT engines are turbocharged.

Press A 5

1

5

OK. Turbochargers usually are standard equipment on CAT engines. The speed of the turbochargers on CAT engines is controlled by restricting the ___(1)___, whereas on Cummins engines, speed is controlled by restricting the___(2)___.

6 A. (1) impeller (2) turbine
7 B. (1) fuel (2) air
8 C. (1) air (2) fuel

1

6

No. You said restricting the impeller on CAT engines controls the speed; this is incorrect. CAT controls the air (exhaust) through a by-passing arrangement which controls the speed of the turbine. Cummins, on the other hand, controls the flow of fuel. However, the same end result is accomplished.

Press B 8

1

7

No. You have it turned around.

CAT controls the turbocharger speed through by-passing exhaust air around the impeller.

Cummins controls the speed by restricting fuel to the injectors.

Press A 8

1

8

CF. Turbocharged engines are equipped with after coolers (heat exchangers) for the purpose of_____.

9 A. compressing the air
9 B. additional filtering of the air
10 C. neither A or B

1

No. An after cooler (heat exchanger) on a turbocharged engine is not used for compressing the air or for additional filtering. It serves to cool the heated air, which has been compressed by the impeller in hot weather, and to heat it in cold weather.

Press A 10

1

10

CI. Neither compressing the air, nor additional filtering of the air is the purpose of the after cooler. It is used to cool the compressed air in hot weather, or heat it in cold weather.

In Cat engines, heating and cooling of the air is accomplished by_____.

11 A. the oil system
12 B. the cooling system
11 C. neither A or B

1

11

If you said it was the oil system or that it was neither the oil or cooling system, you are incorrect.

It is the coolant being circulated through the cooler that does the job.

Press A 12

1

12

CA. Coolant circulating through the element reduced or increases the air temperature being forced into the intake valves. The reason this air is hot and has to be cooled is due to_____.

13 A. heat absorption from the starting engine exhaust
15 B. compressing air makes it hotter
14 C. the venturi principle set up by the intake valves

1

13

No. The exhaust from the starting engine only heats the intake manifold air in the initial starting of the diesel. Once it is running the starting engine is shut down.

The correct answer is:' when air is compressed, as it is by the impeller action, it gets hot; hence the purpose of the after cooler.

Press B 15

1

14

No. The answer we want here is: the air is heated through compression by the impeller action. This condition, if left unchecked, would defeat the purpose of the turbocharger; hence, the air must be cooled.

Press A 15

1

15

OK. The air must be cooled to the right density so that the maximum efficiency of the extra amount of air being forced into the cylinders does its job. Remember, we said when air is compressed such as it is by the impeller, it gets hot. When air is hot it is less dense than it is when cool, hence, the after cooler.

Press B 16

1

16

Much has been said about air cleaners..... Perhaps clean air is the most important factor in keeping diesel engines running efficiently.

There are some air cleaners, on the market today, that are unique compared to the conventional types, in that they_____.

17 A. are capable of removing more dust from the air
17 B. can go longer without a filter element change
18 C. utilize the exhaust to remove dust

1

17

No. All filters of approximately the same size can remove about the same amount of dust, and all of them need a filter cartridge change about the same time, but some cleaners have a unique feature in that they remove dust particles from the air cleaner housing by utilizing the exhaust.

Press A 18

1

18

Ok. Through the venturi principle of suction, dust particles are drawn from the dust bin by the aspirator attachment.

In our study of the CAT engine we learned that there is a priority valve. This valve_____.

19 A. regulates the amount of oil flowing to various engine components
20 B. permits only filtered oil to flow through it
21 C. opens only after the turbocharger has oil

1

19

No. This valve provides a stop to the oil flow throughout the engine until the turbocharger has been lubricated. It is a safety device to protect the turbocharger bearings. It opens only after these bearings are lubricated.

Press A 21

1

20

No. When the engine is first started, unfiltered oil is forced to the turbocharger bearings. When the turbocharger has oil, then the valves open and oil is circulated throughout the engine.

Press A 21

1

21

Ok. The priority valve might easily have been named a safety valve for the turbocharger bearings.

The series A and B Cat engine is unique in that it is equipped_____.

22 A. with valve rotators
24 B. without valve rocker arms
23 C. with independently driven overhead camshafts

1

22

No. Valve rotators are common to all CAT engines. As you will recall, the mechanism consists of five springs and five steel balls which rotate the valves approximately 30 degrees every time they are lifted from the valve seats. Try this question again.

Press B 21

1

23

No. You are only partially correct in saying that there are two overhead cams but they are not independently driven. Only one is driven by the gear train, which in turn drives the other one. The correct answer is: the CAT A and B model engines do not have valve rocker arms (bridges). The camshaft lobes are in direct contact with the cam followers.

Press A 24

1

24

OK. The camshaft lobes are in direct contact with the cam followers.

Troubleshooting the air system. Due to the position of the air pressure ratio control regulator, (see Plate I) if the valve should be stuck open_____.

27 A. the turbine might overspeed
26 B. the engine would be sluggish

X (C)-25

2

25

You have answered one or more of the questions in this last sequence of material incorrectly. Before going on, review this part again. Read carefully and take your time in answering.

Press B 2

2

26

No. Look at Plate I: If (9) is open, the exhaust gases will by-pass the turbine wheel, not cause it to overspeed. If this happens, the engine would lack power and would smoke.

Press A 27

2

27

OK. The exhaust gases would be by-passing the turbine, should the valve be stuck open. Check the CAT maintenance manual for proper servicing procedures of this valve.

On the turbocharger, there is no way to inspect the bearing condition without disassembling it.

28 A. True
29 B. False

2

28

No. You are incorrect. The bearing condition can be checked by inspecting to see if the turbine or impeller wheels have been rubbing against the turbocharger housing.

Press A 29

2

29

OK. Let's review some important points about the CAT fuel system.

Between the fuel transfer pump and the spring loaded by-pass valve, approximately_____ pounds pressure is maintained in fuel filter housing and fuel injection pump housing.

30 A. 15
30 B. 2500
32 C. 35

2

30

No. Approximately 25 pounds pressure is maintained by these two components. The high pressure needed to force fuel into the cylinders is provided by the_____.

31 A. spray injectors
32 B. multi-piston fuel pump
31 C. both A and B

2

31

No. On CAT engines it is action of the fuel pump that produces the high pressure necessary to force fuel into the cylinder. The nozzle is only a dispenser and a means of obtaining the correct fuel supply pattern.

Press A 32

2

22

C1. Actual metering of the fuel is done by the _____ movement of the plungers in the fuel pump.

34 A. rotational
33 B. vertical
33 C. neither A or B

2

No. Vertical motion of the plungers serves to compress the fuel that is trapped in the groove or scroll of the plunger. The rotation is the action that accomplishes the metering.

Press A 34

2

24

Correct. Plate II shows a schematic of a fuel flow system in a six cylinder CAT engine. Examine Plate II carefully. Which of the following components are part of the supply side of this system?

35 A. 1,4,5,6 and 11
36 B. 3,5,10 and 16
35 C. 4,5,6,7 and 8

2

No. Remember, all components from the supply tank to the fuel pump are part of the supply side of the system. Here the pressure is approximately 25 lbs or less. Once it enters the pump plungers it is in the fuel injection side of the system. The fuel injection nozzles and lines are part of the injection system.

Press A 36

2

36

A.

A low pressure indication on No. 4 (Plate II) would indicate there is a faulty fuel transfer pump. This is _____.

38 A. true
37 B. false

2

27

No. The answer to this is true. A faulty fuel transfer pump is one of a number of things that could cause this low pressure indication. Others are: an empty fuel tank, clogged filters, dirt under the bypass valve, or an open vent valve.

Press A 38

2

38

A. There are other malfunctions that could cause a low pressure indication, but it could be a faulty transfer pump.

If the pressure gauge falls back toward the low range gradually, it is usually a sign that the _____.

40 A. filters are clogged
39 B. fuel tank is empty
39 C. bypass valve is stuck

2

39

No. If either of these two things happened -- the fuel tank was emptying, or the bypass valve was stuck -- there would be a sharp drop of the needle on the pressure gauge. A gradual drop would indicate the fuel filters are clogged.

Press A 40

2

40

OK. Before moving on to the injection side of the fuel system, let's review the three important maintenance rules about the supply side.

First, every 50 hours of service, drain the filter housing to remove accumulations of sediment and moisture. Before installing new filter elements, always drain and flush the filter housing.

Press 41

2

4

Second, never open the fuel filter housing unless fuel filter elements are to be changed. The fuel filter gauge, as mentioned earlier, is the best method of telling if the filters need changing -- nothing is gained by looking at the filters. Opening the filter housing for a visual check only increases the possibility of getting dirt into the system.

Third, always clean the filter housing cover and around the edges of the gasket joint before it is removed to install new filter elements. This prevents dirt from dropping into the filter housing when the cover is removed.

Press A 42

2

42

INJECTION SIDE OF THE FUEL SYSTEM -- There are two distinct functions that the fuel pump performs; it ___(1)___ and ___(2)___ the fuel.

43 A. (1) transfers (2) pressurizes
45 B. (1) meters (2) pressurizes

X (C) 44

3

43

No. The transfer pump moves the fuel through the system to the fuel pump.

You are right about it pressurizing the fuel.

Press A 45

3

44

You have answered one or more of the questions in this sequence incorrectly. Review this material once more and read carefully. Take your time in answering the questions.

Press A 27

3

45

(B). The pump meters the amount of fuel, then pressurizes it.

The pressurizing of the fuel ___(1)___ be varied due to the ___(2)___ on the ___(3)___.

46 A. (1) can (2) teeth (3) fuel port
47 B. (1) cannot (2) lobes (3) camshaft
46 C. (1) can (2) movement (3) throttle

3

46

(A). The plunger stroke is fixed by movement of the cam lobes. Thus, any fuel trapped within the scroll or helix cuts on the plungers will be pressurized the same amount on every stroke.

Press A 47

3

47

(B). The pressurizing is fixed by the lobes from the camshaft moving the plungers up and down. Any fuel trapped in the plunger is always pressurized the same amount.

Each plunger cylinder has a check valve located at the top of the pump body. The purpose of this valve is to ___.

48 A. vent the cylinder of trapped air
48 B. allow fuel to leave the cylinder
49 C. keep the fuel lines filled with fuel

3

48

No. This check valve (sometimes referred to as the delivery valve) keeps the fuel line between the pump and spray nozzle full of fuel at all times.

Press A 49

3

41

Correct. The fuel lines are kept full to keep the pump from refilling them on each pumping stroke.

The nozzle and body of the spray nozzles should be assembled only finger tight because_____ _____.

50 A. torquing is done after complete assembly
52 B. there must be a clearance left
51 C. this is required for the popping test

3

50

No. These nozzles must be assembled only finger tight so a clearance will be left for fuel to enter the nozzle assembly from the valve body.

Press A 52

3

51

No. The popping test has nothing to do with assembly of these nozzles. There must be a clearance between the threads (which are coarse) to allow fuel to enter the nozzle assembly from the valve body.

Press A 52

3

52

OK. Let's discuss some facts about fuel timing controls.

The CAT speed sensing variable timing unit is a device that retards fuel injection until the piston has been raised to a certain point in the diesel engine cylinder.

54 A. True
53 B. False

3

53

No. The speed sensing variable timing unit does retard fuel injection until the piston has risen further in the cylinder, thereby increasing compression pressure and also increasing heat for ignition at the time of injection.

Press A 54

3

54

OK. This unit greatly aids in starting the engine because, if fuel is injected late, the compression pressure has risen and also the heat is at a higher level.

Rack Limiter -- The rack limiter is a device that CAT uses to_____.

55 A. limit the possibility of overspeeding the engine
56 B. limit the fuel rack movement until sufficient combustion can occur
55 C. stop the fuel rack at low idle to prevent engine from dying

3

55

No. You are incorrect. Both the high speed and low speed of the CAT engine are controlled by the governor. The rack limiter is a device which operates on manifold pressure. It limits fuel rack movement until sufficient pressure has built up in the inlet manifold to furnish good combustion.

Press A 56

3

56

OK. The rack limiter operates much the same way as the aneroid control on the Cummins engine. It will not reduce engine power or rate of acceleration if adjusted properly.

In summarizing the CAT fuel system, let's review some important maintenance tips:

(1) Do not remove the injection nozzles, or any parts of the fuel system until all other possibilities are checked. Unnecessary removal of these components only increases the possibility of dirt entering the system.

Press A 57

3

57

As previously mentioned, the fuel lines running from the pump to the injector nozzles are the same length. It is important that these lines do not become bent or dented in any way which could cause a restriction in fuel flow.

Damaged lines should be replaced in sets. Do not try to bend one to fit.

Use clean fuel and keep it clean by changing filters regularly. Always drain and flush the filter housings before inserting new filters.

Always keep the fuel tank full, when possible, to prevent moisture accumulation.

Press A 58

3

58

CAT Cooling System -- The CAT engine cooling system, like most diesels today, has a pressurized cooling system. There are two reasons for this. One reason is_____.

60 A. force the coolant into hard-to-reach places and keep corrosion to a minimum

61 B. force any entrapped air away from the cylinder head

X (C) 59

4

59

You missed one or more of the questions in this sequence. Review it again. Read carefully and take your time before answering.

Press A 42

4

60

A. Coolant could reach all areas without the system being pressurized; and pressurized systems do not aid in keeping the corrosion down. The answer we want here is that pressurized systems help force entrapped air to the highest points in the system, where it can be removed.

Press A 61

4

61

CK. Pressurized systems help remove entrapped air from critical parts of the engine that could cause hot spots if air came between the coolant and the surface.

Another reason for pressurized cooling systems, particularly for those vehicles that operate at critical angles, is prevention of coolant loss on a downhill operation.

As we learned earlier, special attention must be given to cooling systems in cold weather, even more so in extreme cold weather. The right mixture of ethylene glycol (permanent anti-freeze) and water must be used for safe operation. For extreme cold weather (40 degrees and below) pure ethylene glycol should be used in the cooling system. This statement is_____.

62 A. True 63 B. False 4

62

No. You are incorrect. Pure ethylene glycol freezes about 10 degrees above zero. The solution must be made up of 50% water and 50% ethylene glycol. This solution is good to approximately 60 degrees below zero.

Press A 63

4

63

OK. Let's talk about maintaining the cooling system. Components of the cooling system that must be inspected and maintained regularly are:

1. Radiator - the radiator must be free of obstructions and bent fins. These two conditions will limit the effectiveness of the cooling system.

2. Fan belts - Fan belts can neither be too tight or too loose. Loose belts slip, whereas overtightened belts can damage pulley bearings. Also, make sure the belts are not greasy. Inspect them regularly.

64

4

64

Draining - Whenever the cooling system is to be drained, be sure all the drain cocks are open. Trapped coolant and sediment remaining in the engine can only cause problems later.

Adding coolant - Many a cylinder head has been cracked by adding cold water to a hot engine. The reason this happens is:_____.

65 A. immediate contact of cold water to hot, produces steam causing expansion
66 B. adding cold water makes metal expand too rapidly
67 C. adding cold water makes metal contract too rapidly

4

65

No. Steam within the engine is caused by shutting the engine down when it is hot. The water cannot circulate while gradual cooling occurs in the engine parts, hence steam is produced. Try this question again.

Press A 64

4

66

No. You are incorrect. It is the opposite way around. Adding cold water to hot metal makes the metal contract, not expand. Too rapid a contraction of the metal can crack it.

Press A 67

4

67

OK. Adding cold water to a hot engine is a bad practice. If it is absolutely necessary to do this, allow the engine to idle, and add the coolant slowly. Rapid contraction of metal can cause severe cracking.

Overheating complaint - When an operator complains that the vehicle is overheating, a smart mechanic would first_____.

68 A. check for scale deposits around the cylinder liners
68 B. change the thermostats
69 C. check coolant level, then check with an accurate thermometer

4

68

No. Both checking for scale and changing thermostats involve a lot of work that may not be the problem at all. A good mechanic will use a methodical approach to any problem. In this case, he will check what he can without removing any components.

Press A 69

4

69

OK. The coolant level may be low or it may be a faulty gauge giving the operator a false reading. Remember, use a methodical approach to troubleshooting. Remove components as a last resort.

CAT Toney engine - the Caterpillar starting engines are independently (1), (2) cycle gasoline engines used for starting the diesel engine.

70 A. (1) cooled (2) four
71 B. (1) lubricated (2) four
70 C. (1) lubricated (2) two

4

70

No. You are incorrect. The Cat engine is independently lubricated and is a four cycle engine.

Press A 71

4

71

OK. Cat makes two starting engines. The smallest is 2 3/8" bore with a 2 3/8" stroke. This engine is used on all applications up to the 5.4 diesel engine. The larger engine is a 3 3/8" bore with a 4" stroke. Both engines are independently lubricated, having their own oil pumps. Cooling is accomplished by using the diesel cooling system.

Press B 72

4

72

Neither engine has a fuel pump. There is no need for one because_____.

73 A. fuel is pumped to it from the diesel fuel pump

75 B. it has a gravity flow arrangement

74 C. fuel is under air pressure

4

73

No. You are incorrect. Fuel is not pumped from the diesel fuel pump. This is a gasoline engine and does not operate on diesel fuel. The correct answer is: it has a gravity flow arrangement to the carburetor.

Press A 75

4

74

No. The fuel (gasoline) is not under pressure. This engine has a gravity flow arrangement to the carburetor, which permits the engine to run continuously, as long as the fuel lasts.

Press B 75

4

75

OK. There is a gravity flow arrangement which allows fuel to flow to the carburetor as long as the fuel lasts. The fuel line has a shut-off valve which should be closed when the engine is not running.

The carburetor is of the down-draft type with two adjustments. The small adjustment is used for idling; the large metering valve is used for all other adjustments other than idling.

Press C 76

76

Electrical system - There has been much discussion about the electrical system of this engine. Let's see how much we understand about it.

The magneto is a device used for_____.

77 A. starting the engine

79 B. igniting the fuel

78 C. a timing adjustment

4

77

No. You are incorrect. The engine is started by a battery, or other means. The magneto is used to supply the spark plugs with the correct amount of spark, at the right time, to enable the engine to fire.

Press A 79

4

78

No. You are incorrect. The magneto is not a timing adjustment. It must be timed to the engine, however, for the engine to fire correctly, because it furnishes the right amount of sparks to the spark plugs to enable the engine to fire.

Press B 79

4

79

OK. The magneto supplies electrical spark to the spark plugs to enable firing of the engine.

It is of vital importance that the magneto be in perfect time with the camshaft rotation. To do this, rotate the engine until No. 1 piston is at top dead center. Then align the X (see Plate III) on the tang of the magneto with the X in the groove on the starting engine camshaft. After aligning is correct, bolt them together; after this there is no way to alter the timing.

Press C 80

4

80

The magneto rotates at approximately ___(1)___ speed as the crankshaft and ___(2)___ speed of the camshaft in this starting engine.

81 A. (1) the same (2) at half
82 B. (1) half (2) the same
81 C. (1) half (2) at half

4

81

No. You are incorrect. The magneto rotates at half speed with the crankshaft, and at the same speed as the camshaft which is the magneto's driving force.

Press A 82

4

82

C. In four cycle engines, magnetos rotate at half speed of the crankshaft and the same speed of the camshaft, the latter being the magneto's driving force.

Congratulations, you have completed the last film on the study of Caterpillar engines.

Please Press REWIND

X(C) 83

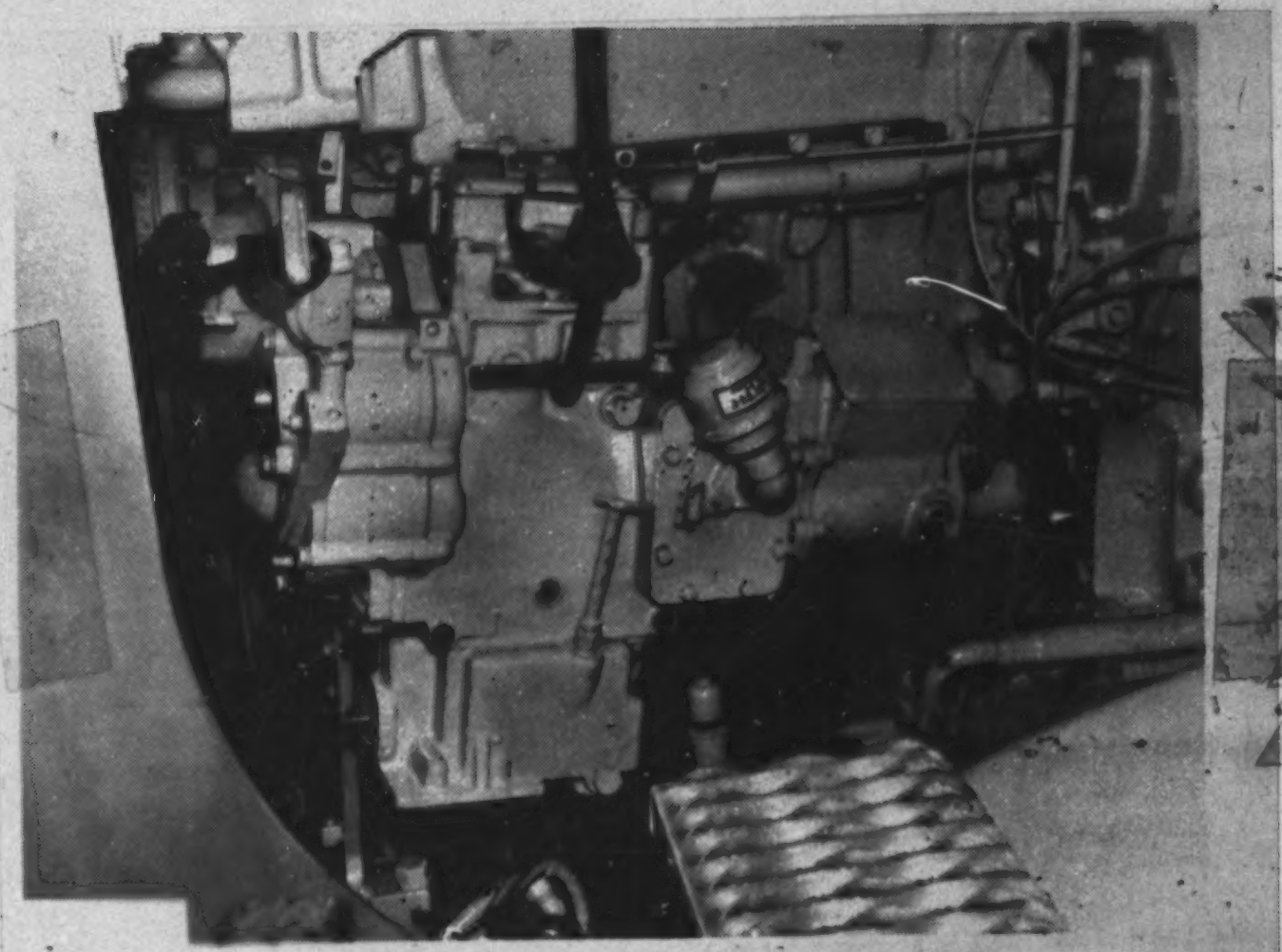
4

83

You have failed to answer all the questions correctly in this last sequence of material. Please review the last few frames again. Read carefully and take your time before answering.

Press A 58

4



REMOVING STARTING ENGINE

AM1-30 (1)

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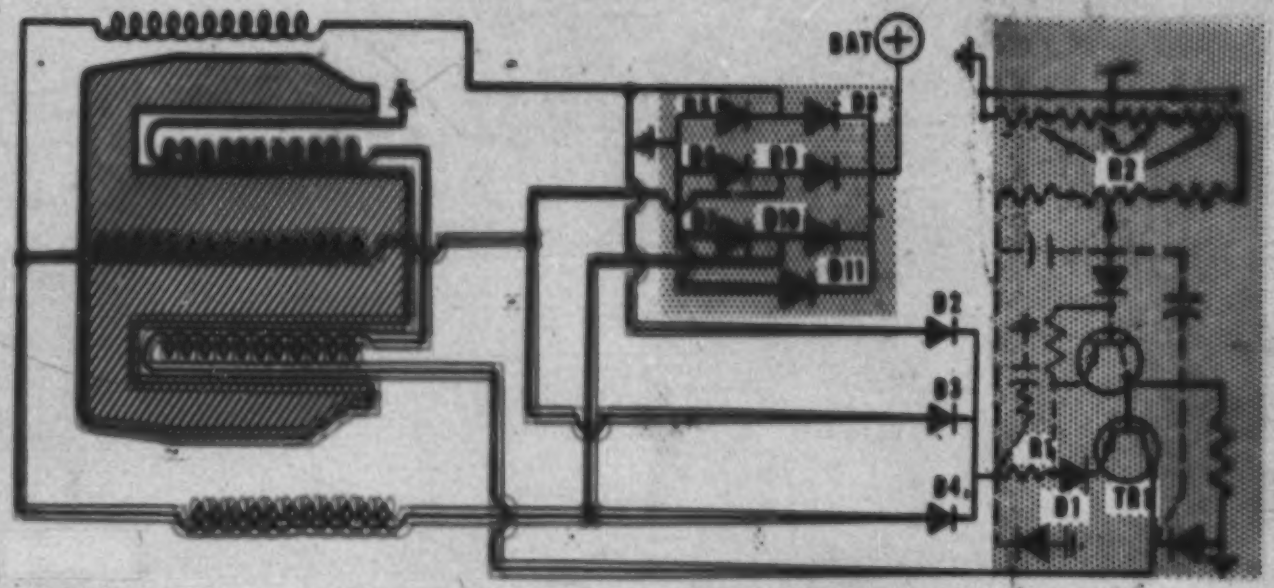
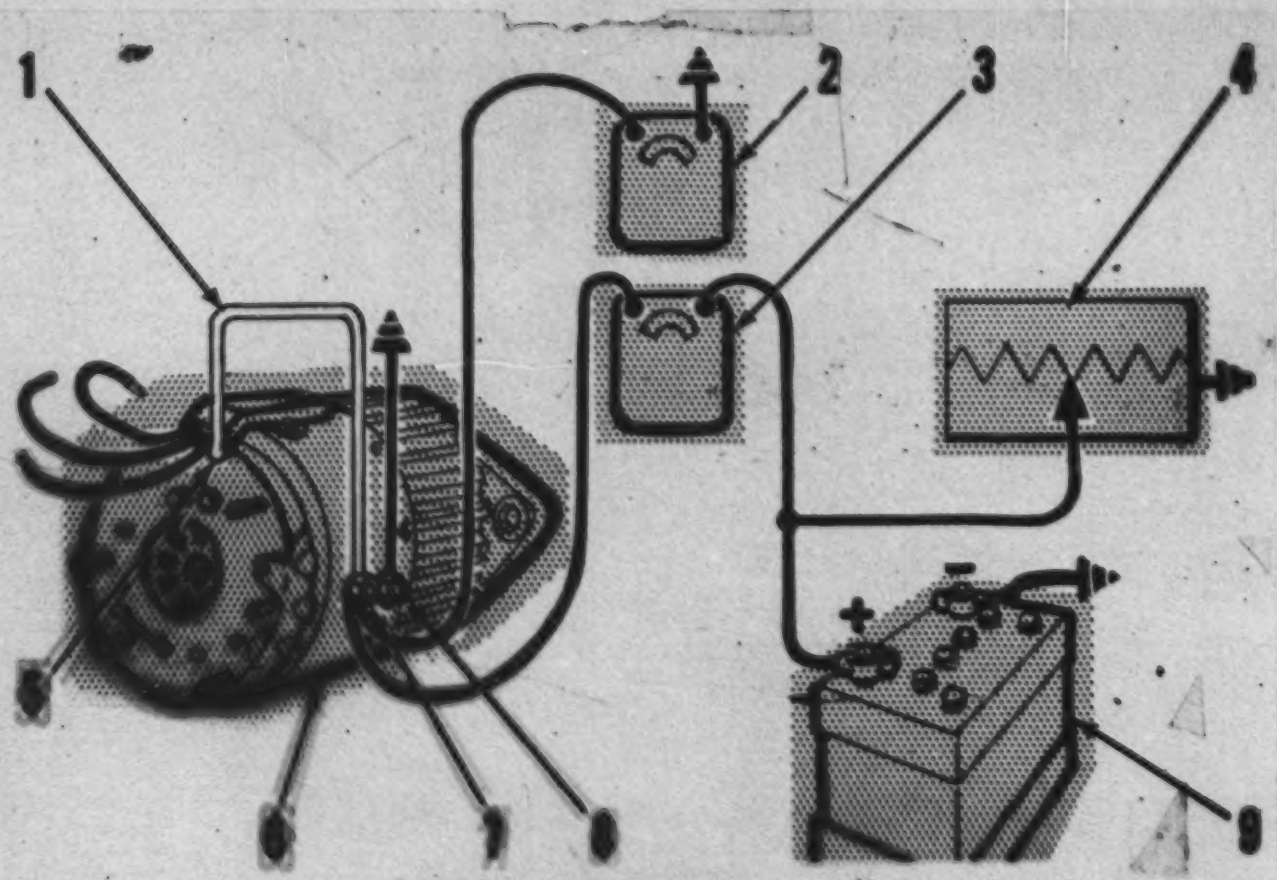


WIRING DIAGRAM (24 VOLT)

AM1-30



TESTING SCHEMATIC

1–Jumper lead. 2–Voltmeter. 3–Ammeter. 4–Carbon pile. 5–Field wire (red). 6–Charging alternator. 7–Output terminal. 8–Ground terminal. 9–Battery.

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Cleveland, Ohio 44115

EXECUTIVE DEVELOPMENT • SUPERVISORY TRAINING • [illegible] AND MAINTENANCE EMPLOYEES
PERSONNEL TESTING • EYE AND [illegible] • [illegible] AND COUNSELING

INSTRUCTOR'S GUIDE

Title of Unit: I - CATERPILLAR DIESEL ENGINE MAINTENANCE SUMMARY
II - REVIEWING FACTS ABOUT ALTERNATORS

AM 1-30
11-11-66

OBJECTIVES for this Unit:

1. To wind up the ten units on Caterpillar equipment by discussing troubleshooting; what to look for when the equipment acts a certain way -- such as black smoke, no response to governor, etc.
2. To give the student a review of the Cat starting engine, plus some troubleshooting tips of this engine.
3. To be sure the student is aware of how the alternator operates.

LEARNING AIDS suggested:

VU-CELLS: AM 1-30 (1) Removing starting engine
AM 1-30 (2) Wiring diagram - 24 volt
AM 1-30 (3) Testing schematic

PROBLEMS: Perhaps a round-table discussion on problems incurred with Cat equipment would help here. In a session like this, there usually are one or more students who have had unique problems with the equipment that are interesting and lends themselves to class discussion.

MODELS: Bring an alternator to class. Disassemble it and pass the parts around class. Let the students re-assemble it.

TEST: Perhaps an actual test of the alternator could be conducted in class.

QUESTIONS FOR DISCUSSION AND GROUP PARTICIPATION:

1. What could be wrong when black smoke and lack of power occur with Cat equipment?
2. How can back pressure be checked? What should the reading be?
3. What is the purpose of the 24" tube in checking the rack limiter diaphragm?
4. What should you do when there is no governor response and the engine runs at one speed and misses?
5. On engines having vibration dampers, if the damper is cold to the touch after running, what is wrong?

6. Would a broken crankshaft cause unusual vibrations at certain engine rpm's?
7. What should you do if the starting engine will not turn over?
8. What is the proper procedure for checking to see if the magneto has the correct spark?
9. Where is the alternator located?
10. Does an alternator produce AC or DC voltage? How is this voltage rectified?
11. What is the ideal voltage setting of a voltage regulator?